Static Analysis of 3 Cubic Meter Tractor Trailer

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Abstract—*Most of the truck manufacturers have been confronted with ever more increasing demands on their products and on the development process. These demands are reflected in higher engine power, lower vehicle noise, higher fuel economy and shorter lead times in development. Increasing engine power and higher power density, resulting in a higher loading of the driveline and more severe use of vehicles, set higher demands on the laudability and the endurance capability of the rear axle gears have increase, as well as a decreasing interior noise level which is considered as a quality item for commercial vehicles, also set high demands on the noise level of gear axle gears. The need for fuel economy gives even more demand on the mechanical efficiency of the driveline in general and on the rear axle gears specifically. Rear axle efficiency under typical highway conditions, high speed and low torque is required to be low for the vehicle overall fuel consumption. In this paper focus on Hypoid gear design which is more import component in rear axle gear drive.*

Keywords: - 3 Cubic meter Tractor Trailer, Static Analysis

I. INTRODUCTION

To during service, any trailer is subjected to loads that cause stresses, vibrations and noise in the different components of its structure. This requires appropriate strength, stiffness and fatigue properties of the components to be able to stand these loads. On top of that, quality of a trailer, as a system, which include efficient energy consumption, safety, and provision of comfort to the user are highly desired.

All the above largely demand refined and complex design and manufacturing procedures involved during the production stage. This, in turn, requires good understanding of the internal systems of the trailer and the characteristics of the different body structures in reaction to static and dynamic loads.

Vehicle dynamics, a discipline of broader significance, is an area where the basics of analyses on vehicles are dealt with. Forces/loads acting on vehicles can be categorized as road, aerodynamic, and gravity loads. Of all these, forces and moments generated by tires at the ground are significant in controlling motion of the vehicle. The response of the vehicle structures to these loads are dealt within vehicle dynamics.

The responses of a trailer are defined in terms of deflections, stresses, and strains, natural frequencies, random response functions, and fatigue life and soon. Evaluation of the above is what puts the basis on which robustness of a vehicle system design is a ascertained in terms of its mechanical behavior. Simulation of vehicle responses largely concentrates on determination of the above.

Different researches have been carried out regarding the performance, the response of components to static and dynamic loads, crash worthiness, safety and others by different institutions and automotive companies. Particularly, with the growing simulation capability using computers, researches are facilitated that are aimed at achieving better quality products.

II. TECHNICAL SPECIFICATION OF 3 CUBIC METER TRACTOR TRAILER

Table 1 Technical Specification of 3 Cubic Meter Tractor Trailer

Item No	Item	Specification	Justification and remarks
1	Capacity	The trailer shall be of 3 cubic meter capacity.	A 3 m³ capacity gives a payload of approximately 5 tonnes. This is within the haulage capacity of a 55 to 65 hp tractor. Given a small hauler, this size maintains a balance between Loading /offloading time, and travel time. It also maintains a balance between the weight of the load and the strength of the trailer. Its relatively small size enables greater maneuverability on narrow roads.
2	Size	The trailer shall have the following dimensions: Height to top of body 1300 mm Overall length 4800 mm Overall width 2550 mm Drawbar length 1130 mm Inside dimensions of bucket:	The relatively low sides make for easy hand loading. The long drawbar prevents the rear tractor wheels fouling the bucket during sharp turning. The overall width is governed by the narrowness of the roads, and by highway regulations. The depth of the bucket is limited at the bottom end by hitch height and on top by the size of the human frame.

		Top width 2000 mm Bottom width 1500 mm Length 3150 mm Depth 555 mm	Front and rear gussets could be added for additional strength.
3	Shape	The bucket shall have sloping sides, sloping front, and an angled back.	The sloping front and sides contribute to the ease of unloading. Sloping front and sides make for a stronger design than a rectangular shape. A rectangular box shape was tried but found to be weaker. The sloping back allows for the natural repose angle of the spoil.
4	Body	The body of the trailer (the bucket) shall be all steel plate of 3 mm thickness reinforced by cold pressed steel channel of 40 x 80 x 3 mm at intervals as shown on the attached drawings. Two drainage holes shall be made at the front.	The thickness of the steel body copes with the rough loading of heavy material. In areas of high corrosion, e.g.at the coast, the use of 4mm plate could be considered. **NB** This is an integral design. Arbitrary modifications, such as cutting doors in the bucket, may weaken the trailer.
5	Chassis	The chassis shall comprise an A-frame, side members and crossbars, and shall be of U-shaped channels of 160 x 65 x 8 mm welded together as per the attached drawings. Continuous welds shall be used throughout. The middle member of the chassis shall be of two U-shaped channels of 160 x 65 x 8 mm welded together to form the draw bar of 1130 mm in length as per the attached drawings.	The A-frame design gives three-point support to the front of the bucket and prevents failure of the drawbar. The side members and crossbars support the bucket throughout its length and prevent structural failure of the bucket as a whole. Suitable breathing holes should be provided.
6	Axle	The axle shall be made of two U-shaped hot rolled steel channels of 100 x 50 x 6 mm. These shall be welded together with the stub axle welded between them. The axle shall be located 1100mm from the back of the chassis. Total length of the channels 1860 mm. Total length of the stub axle 500 mm (minimum). Tyre size 900 x 20 14 ply. There will be a distance of 100 mm between the top of the wheel and the sloping sides of the body.	This design of axle will bear a rated load of 9000 kg. For rougher conditions, the axle rating could be increased to 10000kg. In this case, you may want to consider tyre sizes of 1100 x 20, 16 ply. A spare tyre could be fitted to the front of the bucket.
7	Towbar	1 Towing eye: To be cut from 32 mm steel plate. Inside hole diameter 50 mm. 2 Towing socket: Internal diameter 80 mm. To be made from cast steel with additives. To fit inside the drawbar.	Over time the towing eye will wear out. This design allows for cheap and simple replacement of the towing eye. This item can be produced by the manufacturer.
8	Painting	One primer coat. Two coats industrial grade paint.	
9	Hitch	The pickup hitch shall be of the hydraulic weight transfer type. It shall have a four-position mounting as indicated in the attached drawings. It shall incorporate a fail-safe locking mechanism. The mountings shall be arranged such that the hitch will accommodate a wide	Weight transfer increases traction and provides for more positive steering. This kind of hitch has a longer life compared with other types, and there is less down time due to hitch failure. The four-position mounting distributes the forces, provides a robust fixing, and results in less maintenance. It also helps to maintain the structural

		range of tractors and models. The pickup hitch must be of heavy duty commercial grade. Ordinary agricultural hitches are too light and will break. Drawings of a suitable heavy duty hitch, designed to be adapted to fit any make and model of tractor, are appended. This design does not involve any complex processes and can be made by a local manufacturer.	integrity of the tractor. The locking mechanism prevents the trailer from parting from the tractor and possibly causing an accident. The universal design ensures that it can be adapted to a wide range of tractor types and models. There are two options for attaching the trailer: pin and eye, or ball and socket. The towing eye fits over the pin; or the towing socket fits over the ball. Either a pin or ball is mounted onto the hitch assembly at the rear of the tractor. This pin or ball is raised and lowered by the tractor's internal hydraulics. The whole arrangement is referred to as an hydraulic pickup hitch.
10	Tractor	1. Power: between 60 and 65 hp (note that effective power declines with altitude, e.g.at 1500m (5000ft) a tractor will have lost 20% of its power). 2. Drive: two-wheel drive. 3. Wheel rims: heavy duty. 4. Tyres: industrial grade. 5Supplier: to have a significant market share in the country. 6.Make and model: see Annexure	Tractors of 60 to 65 horsepower are readily available, and their cost is relatively modest. For mountainous terrain, the power needs to be increased to between 65 and 80 horsepower. Four-wheel drive is unnecessary; two-wheel drive is cheaper. Heavy duty wheel rims are necessary to support sustained heavy working conditions. Industrial grade tyres have a longer working life and are therefore more cost effective. A supplier with a significant market share is more likely to have an adequate supply of spare parts, and to be able to carry out effective servicing and repairs. To improve traction and stability, weights can be added to the front of the tractor. If a PTO shaft is fitted to the tractor, it is better to remove it.

III. FE ANALYSIS OF 3 CUBIC TRACTOR TRAILER IN ANSYS WORK BENCH

A. *Introduction*

The finite element method (FEM), sometimes referred to as finite element analysis (FEA), is a computational technique used to obtain approximate solutions of boundary value problems in engineering. Simply stated, a boundary value problem is a mathematical problem in which one or more dependent variables must satisfy a differential equation everywhere within a known domain of independent variables and satisfy specific conditions on the boundary of the domain. Boundary value problems are also sometimes called field problems. The field is the domain of interest and most often represents a physical structure.

The field variables are the dependent variables of interest governed by the differential equation. The boundary conditions are the specified values of the field variables (or related variables such as derivatives) on the boundaries of the field. Depending on the type of physical problem being analyzed, the field variables may include physical displacement, temperature, heat flux, and fluid velocity to name only a few.

B. *Basic Steps of FEA Analysis*

1) Preprocessing: Defining the problem

The major steps in preprocessing are

(i)Define key points/lines/areas/volumes,

(ii)Define element type and material/geometric properties,

(iii)Mesh lines/areas/ volumes as required. The amount of detail required will depend on the dimensionality of the analysis, i.e., 1D, 2D, ax symmetric, and 3D.

*2) Solution:*assigning loads, constraints, and solving

Here, it is necessary to specify the loads (point or pressure), constraints (translational and rotational), and finally solve the resulting set of equations.

3) Post processing: further processing and viewing of the results

In this stage one may wish to see

- lists of nodal displacements,
- element forces and moments,
- deflection plots, and
- Stress contour diagrams or temperature maps.

C. *Step-1 Pre-processing*

1) First Prepare Assembly in Solidworks 2011 and Save as this assembly as .IGES for Exporting into Ansys Workbench Environment. Import .IGES Model in ANSYS Workbench Simulation Module .

2) Check the Geometry for Meshing.

3) Apply Material for Each Component.

4) Create mesh.

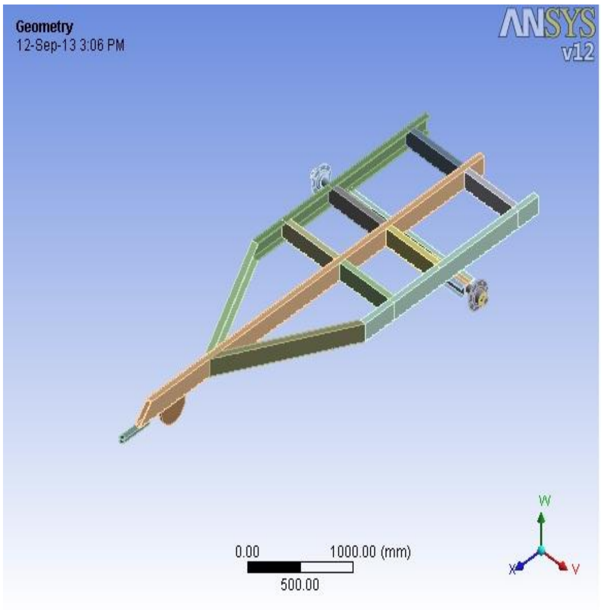
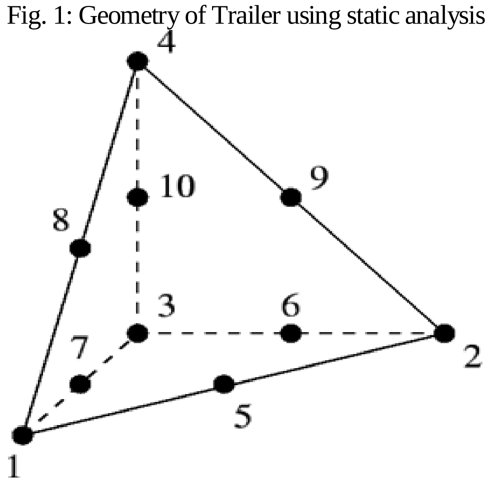


Fig. 1: Geometry of Trailer using static analysis



No. of Nodes:- 28200
No. of Elements:- 15737

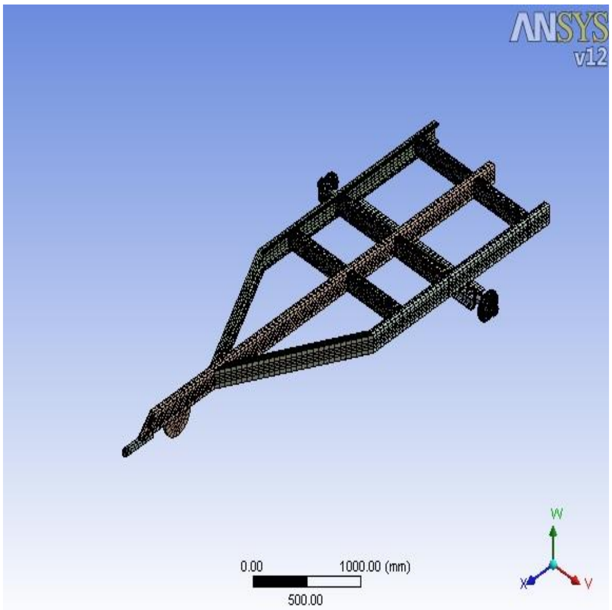


Fig. 2: Meshing of trailer using static analysis

5) Define Boundry condition

D. Apply Fixed Support

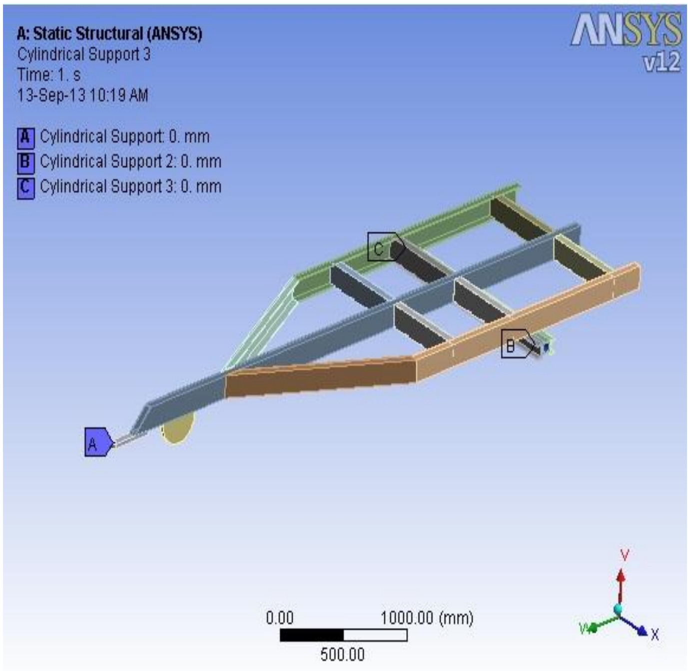


Fig.3: Boundary condition of trailer using static analysis

E. Apply Force

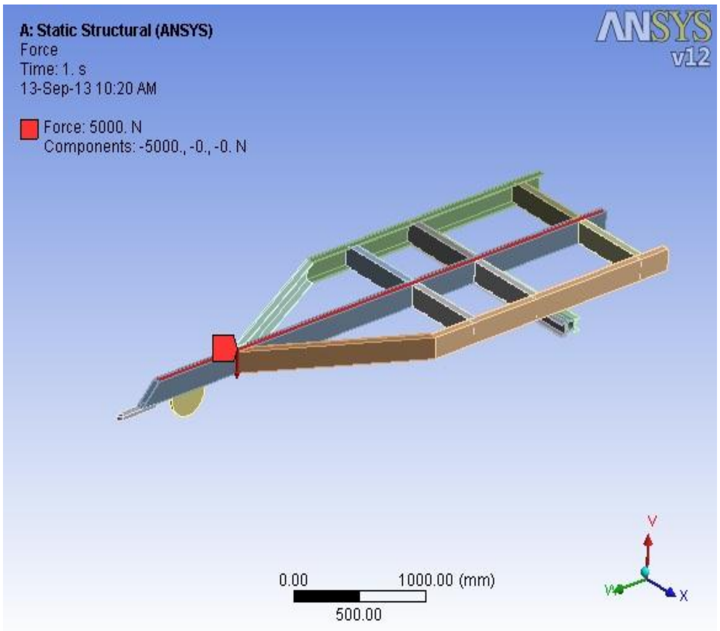


Fig.4: Force analysis of trailer

F. Results of Analysis

G. Equivalent Stress for static annalysis

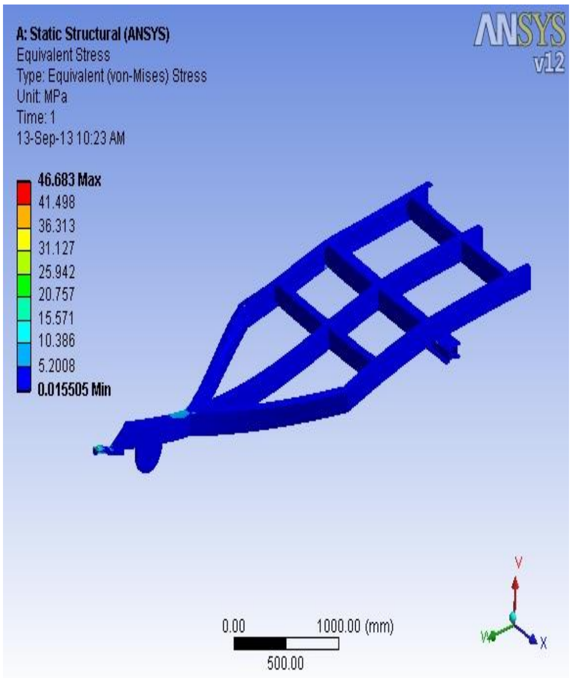


Fig.5: Equivalent Stress analysis of trailer

H. Maximum Shear Stess for static annalysis

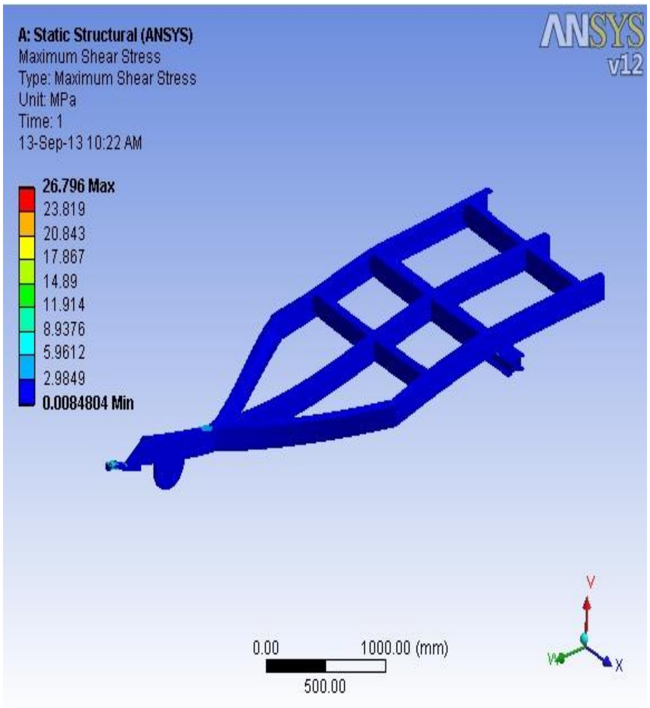


Fig.6: Maximum shear stress analysis of trailer

I. .Total Deformation

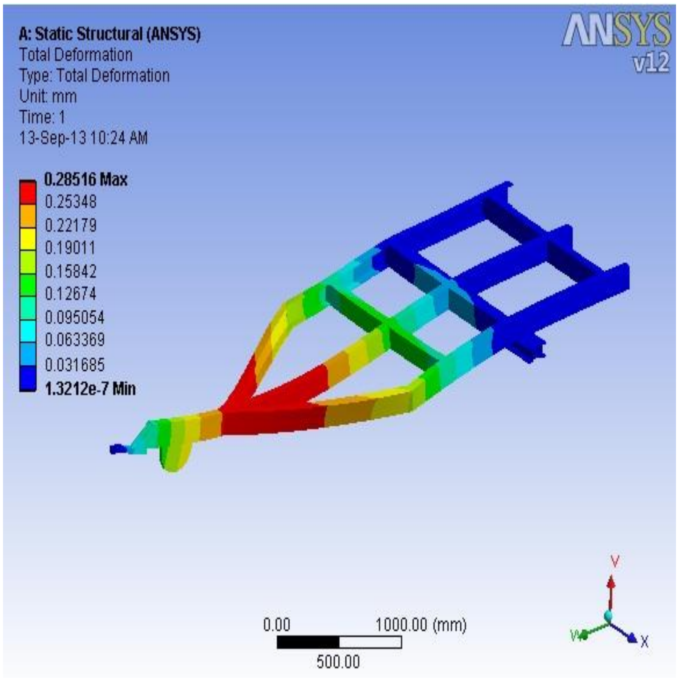


Fig.7: Total deformation of trailer structure

IV. CONCLUSION

In this study, the responses of a commercial vehicle with Trailer are determined under static condition, the results of which are believed to be significant. The analysis includes stress and displacement/deflection responses of the vehicle to the loads. The dynamic analysis is carried out taking into account different road roughness conditions for future works.

From the results obtained in the analysis, the following can be concluded:

The structure, particularly, part of the structure where there is change in cross-section is affected the most by static loads.

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